Space Weather Technical Forecast

Issued on Sunday, 12 February 2023 at 01:22 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of X-flares with M-flares (R1/R2 Radio Blackouts) expected.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: High with an impulsive X1.1 flare observed from AR3217 Ehc/Beta-Gamma-Delta in the southeast disc, peaking at 11/1548 UTC. This is a complex region, but relatively small and compact region with ongoing evolution of its surrounding spots. There are thirteen sunspot groups on the disc, with seven M-class flares observed. These mainly from AR3217, but also the smaller regions AR3208 Dso/Beta and AR3222/Dso Beta near the west limb, along with AR3220 Hsx/alpha to the south east of AR3217. The other large region of interest is AR3213 Fai/Beta-Gamma, which in the northwest, has been active on previous days, but shown signs of simplification through the last 24 hours. AR3214 Dki/Beta in the northwest, remains a simple bipolar group but with some emergence of intermediate spots. The other regions have remained smaller and stable.

A filament eruption in the northeast around 11/1050 UTC, produced a fast CME that is expected to largely miss Earth. However a halo CME was also visible at the same time, perhaps caused by any shock that occurred with the eruption, although this is uncertain. Analysis is still underway to determine any impact this would have. All other CMEs are off the Earth-Sun line.

Solar Wind / Geomagnetic Activity: Solar winds continued to be slightly elevated, with observed speeds at L1 ranging between 450-530 km/s. The density eased from around average to below average. Total IMF strength, Bt, was mainly weak, below 7nT, with the north-south component variable between -5nT and +5 nT. Phi angle was initially positive (away from the Sun) but gradually rotated to negative (towards the Sun). Geomagnetic activity was Quiet to Unsettled (Kp 1-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES-16 remained at Background. The high energy electron flux (greater than 2MeV) measured by GOES-16 was mainly Moderate, peaking at 840pfu at 11/1425 UTC. The associated 24-hour electron fluence was below Active reaching 4.33e7 integrated pfu at 12/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: High to Moderate activity with further M-class flares expected and a chance of X-class flares. The main risk is from AR3217.

Solar Wind / Geomagnetic Activity: Any Earth-directed component from the CME from the filament eruption on the 11th required further assessment, giving low confidence for the geomagnetic forecast. Otherwise a CME which left the Sun on the 10th, while forecast to miss the Earth, give a low chance of glancing interactions on day 3 (14th). Aside from these CMEs, current slightly elevated solar winds are expected to only erratically ease, with no significant enhancements expected. Geomagnetic activity is expected to be mostly Quiet to Unsettled. Any CME glance, however, has the potential to bring a more persistent Unsettled to Active spell, and a very slight chance of G1 Minor Storms day 3 (14th).

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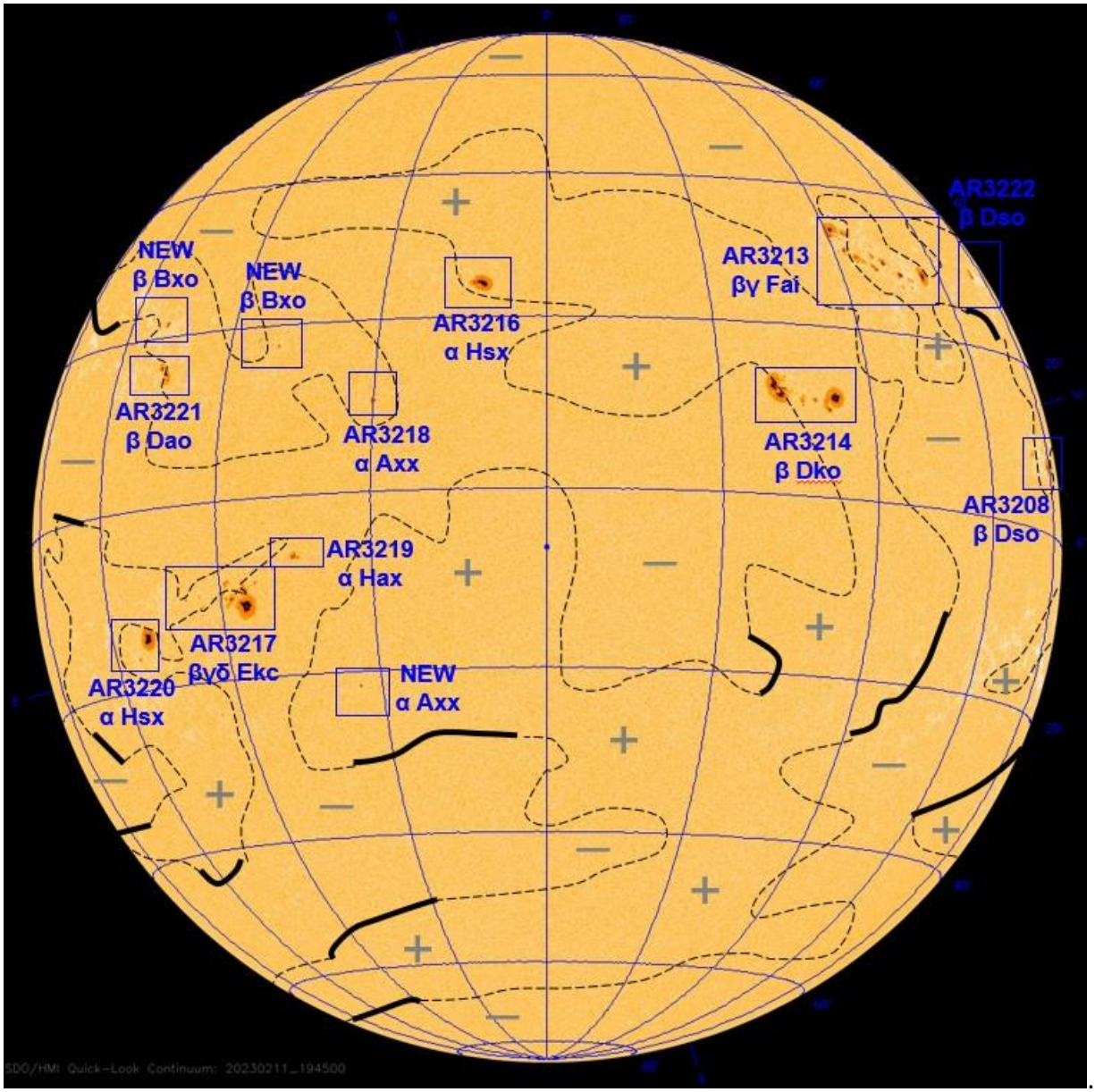
Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at background levels, but with a slight chance of rising in response to any significant flares. High energy (greater than 2 MeV) electron flux is expected to be at Background to Moderate levels, with an overall declining trend. The associated 24 hour fluence is expected to remain below the Active threshold (1e8 integrated pfu)

Figure 1. Solar Analysis Valid 11/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

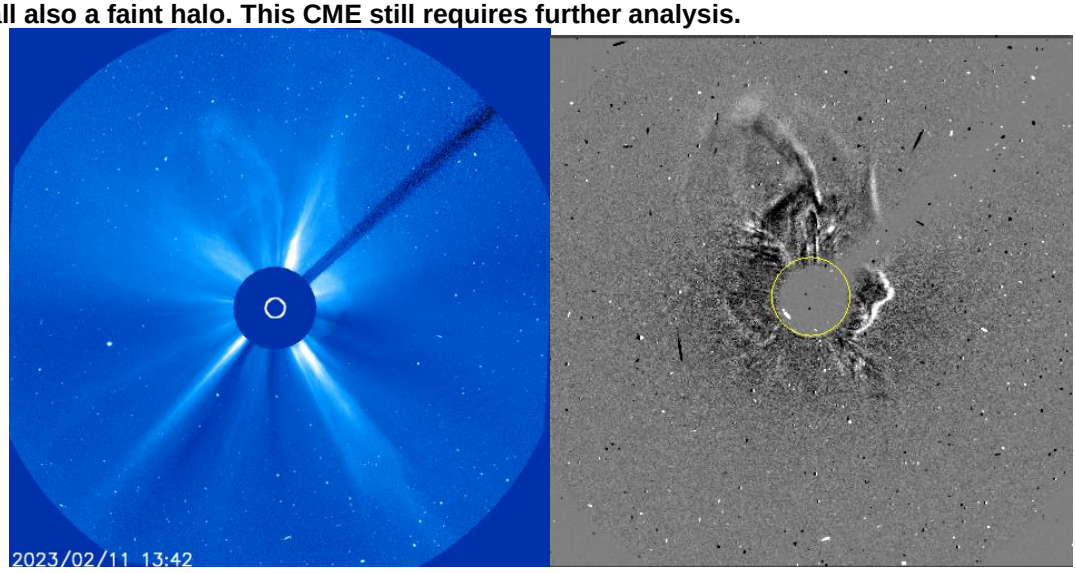
A filament eruption observed in the north centre disc on around 11/1050 UTC produced a fast northward directed CME that is expected to miss Earth. However, LASCO coronagraph imagery also shows a faint halo at the same time. This is perhaps caused by the CME shock but also potentially incorporating some material of the CME. This requires further analysis, and there is additional uncertainty as the CME signal is further contaminated by a far-side CME.

Aside from this there is a further CME which occurred due to a filament lift off in the southwest disc on the 10th. This produced a wide, but slow CME, and is likely to miss Earth, passing ahead and to the south of it on the 14th. However this may also glance Earth. This means that despite no coronal holes being present on the Earth-side of the disc, and enlil giving good guidance for the solar wind in the absence of any CME arrivals, the geomagnetic forecast is currently low confidence.

Geomagnetic activity is expected to be mainly Quiet to Unsettled. Perhaps rising to Active with a slight chance of G1/Minor Storms on the day 3 (14th) due to the southwest filament CME from the 7th. Any arrival from the 11th filament eruption on day 2 (13th) will give the potential for increased geomagnetic activity, however further analysis of the CME is required at this stage.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	1	10	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Figure 2: SOHO LASCO C3 (left) and difference imagery (right) with northern CME visible, but potentiall also a faint halo. This CME still requires further analysis.



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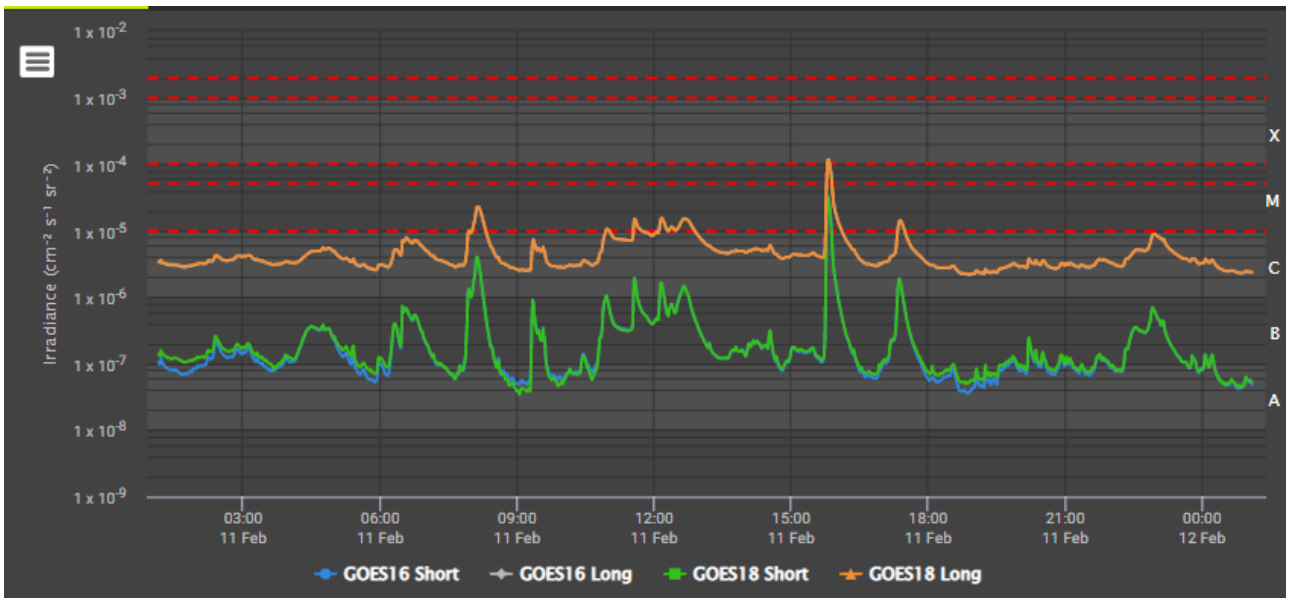
Radio Blackouts - X-Ray Flares:

Moderate to High activity is expected, with thirteen regions currently on the Earth-facing disc. M-class flares are expected with a chance of X-class flares.

The most active region is AR3217 Ehc/Beta-Gamma-Delta in the southeast, which produced an impulsive X1.1 on the 11th. This is a modestly sized but compact region with a small delta spot to the north of its main leader, and given its history of X-class flares, similar sized flaring remains possible. AR3213 Fai/Beta-Gamma in the northwest remains a longitudinally wide region, despite having simplified and reduced in activity over the last day or two. This also brings a risk of notable flaring. AR3214 Dki/Beta is also of note, as another moderately sized region in the northwest. Despite its relative inactivity and simple bipolar configuration, it has seen development of small intermediate spots. All other regions are generally small and simpler, although M-flares have been observed from a couple of small regions near the northwest limb, with further isolated M-flares possible from these regions.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	80	70	60	50
Very Active	R3 to R5 X Class	Yes	30	20	10	10

Figure 3:



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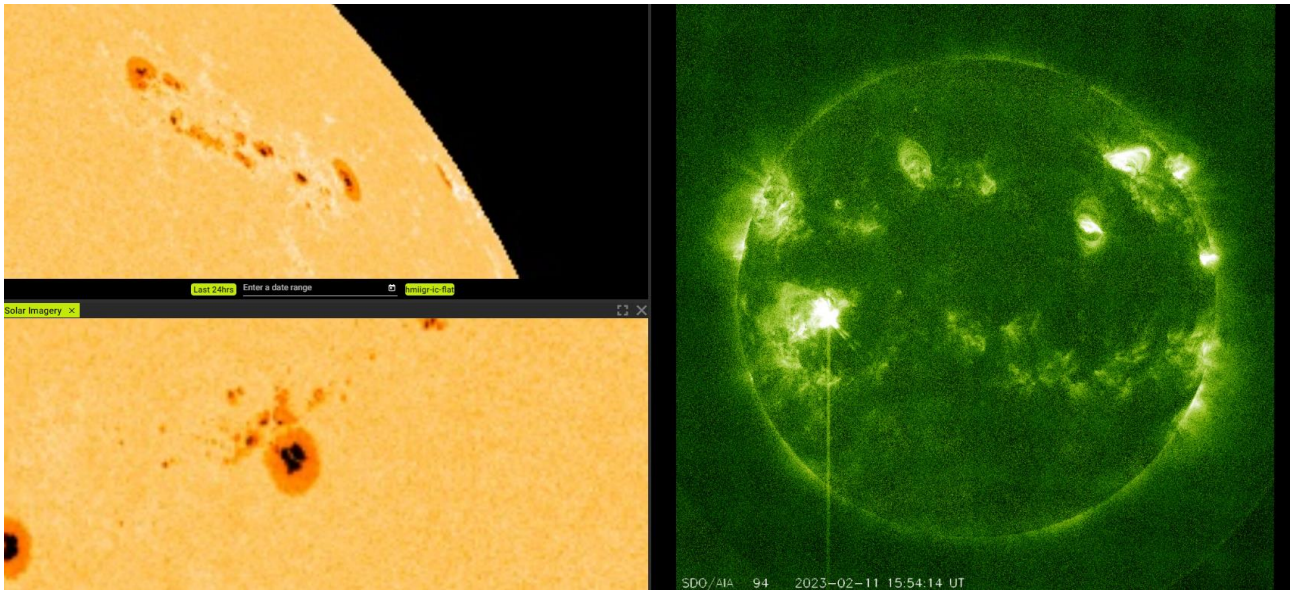
Solar Radiation Storms - (High Energy Protons):

High energy (greater than 10MeV) proton flux as observed by GOES16 is currently at background levels. No notable high energy proton response has been observed from the M-flares and the X-flare on the 11th. Any further significant flares will give a chance of count rates increasing, with a slight chance of exceeding the S1 level. While AR3213 will rotate off the disc day 3 (14th), the proton risk is maintained as AR3217 will have moved into a more favourable location for Earth-directed events.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: SDO intensitygram of AR3213 and AR3217 (left) and SDO-94 showing X-flare of AR3217



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High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux at GOES-16 is expected to continue at Background to Moderate levels with no further notable enhancement expected. Peak values are likely to gradually and erratically decline towards background.

The associated 24 hour fluence is expected to remain below the Active level. This is supported by REFM, which is currently giving good guidance.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	1
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: GOES 16 >2MeV Electron Flux (top) and Fluence with REFM (bottom)

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